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Complexity and conundrums. Citizens' evaluations of potentially contentious novel food technologies using a deliberative discourse approach

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Acknowledgements
We wish to thank the research advisory committee and the participating citizens and scientists for their contributions to this work.

Funding
This research has been undertaken as part of a FIRM (Food Institutional Research Measure) project funded through the Department of Agriculture, Food and the Marine (Ireland) under the National Development Plan 2007-2013.

Abstract

This research considers the processes involved in the formation of attitudes by citizens on potentially contentious novel food technologies (NFTs). Observations of one-to-one deliberative discourses between food scientists and citizens, during which they discussed these technologies, form the basis of this enquiry. This approach enables an exploration of how individuals construct meaning around as well as interpret information about the technologies. Thematic analysis identifies key features that provide the frameworks for citizens' evaluations. How individuals make sense of these technologies is shaped by their beliefs, values and personal characteristics; their perceptions of power and control over the development and sale of NFT related products; and, the extent to which these products are relevant to their personal lives. Internal negotiations between these influences are evident, and evaluations are based on the relative importance of each influence to the individual. Internal conflicts and tensions are associated with citizens' evolving evaluative processes, which may in turn present as attitude ambivalence and instability. Many challenges are linked with engaging with the general public about these technologies, as levels of knowledge, understanding and interest vary.

Keywords

Novel food technologies, citizen acceptance, attitude formation, risk communication, deliberative discourse, thematic analysis.

1. Introduction

Novel food technologies (NFTs) are scientific and technological developments that enhance the way food is produced or processed, which may or may not result in differentiated products for consumers. The public perceive and evaluate both technologies and food in numerous, and sometimes unexpected, ways based on associated meanings that are socially constructed and strongly embedded, i.e. shaped by prior beliefs and expectations. Given the wide array of influences that can intersect and interact in the evaluations of NFTs, it is not surprising that they are not all equally acceptable or homogeneously evaluated.

To date, these technologies have been met with mixed public responses. A review commissioned by the FSA, UK (Fell et al., 2009) found that the majority of Europeans tend to be undecided in their opinions or feel inadequately informed to establish definitive opinions, while a minority are either strongly negative or positive. Negative reactions to irradiated and genetically modified (GM) foods highlight that acceptance cannot be assumed (Henson, 1995; Shaw, 2002) and lack of acceptance can result in significant financial and other losses (Macoubrie, 2006). Public wariness of NFTs is sometimes explained by the evaluative criteria applied, which Cardello et al. (2007) describes as involving perceived rather than actual risks. In fact, Shepherd (2008: 236) suggests that the public may have concerns about food related risks which are outside the *"risk framings"* imposed by scientists and regulators. Communication based on meaningful recognition of public concerns may enhance interaction and engagement

between stakeholders, in turn facilitating more informed public decision making about NFTs (House of Lords, 2010). Many have argued the importance of identifying and incorporating the views of the public at an early stage of technological and product development (Siegrist et al., 2008), since their perspectives can directly (e.g. through outright rejection) and indirectly (e.g. through the imposition of stricter regulations) impact the progress of these technologies (Siegrist, 2010). Given the considerable scale of investment required to develop these technologies, which is frequently funded by the tax payer, it is important to determine the common features underpinning public attitudes towards them, prior to their development/ commercialisation.

Public attitudes towards NFTs have been explored at length, predominately through quantitative methods (e.g., Bredahl, 2001; Grunert et al., 2003; Gaskell et al., 2010); which assume that the attitudes under investigation are stable. Several of these studies have presented models which offer a valuable point of departure for this research. These models suggest that attitudes to nature and technology, perceived knowledge of the technology, social trust and the affect heuristic, among other determinants, are significant predictors of risk and benefit perceptions, and in turn overall attitudes towards and willingness to purchase GM and nano foods (e.g., Bredahl, 2001; Chen & Li, 2007, Siegrist et al., 2007).

A considerable body of work exists that considers the issue of acceptance of NFTs. This work suggests that citizen acceptance is influenced by factors such as knowledge of the technology (Cardello et al., 2007); heuristics, particularly trust and perceived

control (Henson, 1995; Siegrist & Cvetkovich, 2000; López-Vázquez et al., 2012); individuals' risk and benefit perceptions (Cardello, 2003); general attitudes and values; concepts and images associated with the technology (Siegrist, 2008); product characteristics including perceived taste, naturalness and price (Rozin, 2005); the specific technology, application and product in question; and individuals' socio-demographic characteristics (Fell et al., 2009; Rollin et al., 2011).

These influences can be classed as either top-down or bottom-up (Bredahl, 2001; Grunert et al, 2003). Cultural and social norms (Ronteltap et al., 2007) and general attitudes and values, including attitudes towards science and technology, nature and the environment and ethical and moral concerns (Bredahl, 2001; Kahan et al., 2007; Rollin et al., 2011) are commonly cited top-down influences that can shape risk and benefit assessments and also directly shape evaluations of NFTs. Slovic (1987) notes that initial evaluations, framed by these top-down influences, become a core part of final positions taken on a technology, irrespective of any additional contra-evidence presented. That said, information and the sources of such information can impact citizens' attitudes in a variety of ways (Gunes & Tekin, 2006; Rollin et al., 2011).

Focusing on attitude formations, this research explores citizens' evaluations of NFTs in an effort to understand emerging attitudes. Ajzen and Fishbien (1977: 889) argue that *"a person's attitude represents his evaluation of the entity in question"*; however, the operationalization of information processing and formation of attitudes are topics of on-going debate. Broadly examining these issues, attitude formations are guided by the

processing of accessible information (Bohner & Dickel, 2011). Previously held attitudes also influence how information on a new concept is processed and thus the formation of new attitudes (Conrey & Smith, 2007).

Many authors within the area of social psychology define *"attitudes"* as relatively stable entities formed based on associations and evaluations *"stored in memory"*, while others define them as relatively unstable entities and focus on the *"temporary constructions"* guiding attitude formations (see Bohner & Dickel, 2011). Cunningham et al. (2007) consider attitudes to be relatively stable entities, while Conrey and Smith (2007) stress the flexibility of attitude formations, supporting the *"distributed, connectionist"* perspective, which assumes that attitudes occur from the reconstruction of unique configurations of inputs (contextual cues) drawn upon within given contexts. They argue that attitudes are *"time-dependent states of the system rather than as static 'things' that are 'stored' in memory"*, thereby supporting the premise that attitude formations occur *"on the spot"* and are more open to change (*Ibid*: 718).

The provision of information is a key element in the formation of attitudes and thus information processing. Ortony et al. (2005) outline how information processing can occur at reactive, routine and reflective levels. A cognitive component, an emotional component and a behavioural component can influence attitude formations at these different levels (Kazemifard et al., 2005). Edwards (1990: 203) argues that as a result of this *"diversity of attitudes' origins (…) the process of changing an attitude presents a formidable challenge"*.

Closely linked to the concepts of attitude formation and information processing, is that of information framing, which is traditionally referred to from the perspective of media (message) framing of an issue or topic (de Vreese, 2005), i.e. how information senders frame or code a communicated message (Gamson et al., 1992; Scheufele, 2000). Drawing on Reese's (2001) position, that the framing concept should not be restricted in this way, this research focuses on how citizens decode information received and what other information and wider environmental influences they draw on, in order to *"construct meaning"* (Gamson et al., 1992: 373) and form, or change, attitudes. Gamson et al. (1992: 375) highlight the importance of understanding how information is decoded once received, as dominant meanings may not be *"passively accepted by everybody"*. Bearing in mind this context, this research explores the *"mentally stored clusters of ideas that guide individuals' processing of information"* (Entman, 1993: 53); in effect, the factors framing citizens' evaluations of potentially contentious NFTs.

This research contributes to an understanding of how citizens' evaluate (form attitudes around and accept/reject) NFTs by considering responses to information about irradiated foods, GM foods and nanofoods.[1] Factors such as novelty, moral and ethical concerns, stage of development and proximity to the market place, potential types and levels of risks and benefits and likelihood for public debate (Fell et al., 2009; Rollin et al., 2011) guided the selection of these technologies. These technologies form a natural grouping as each of them has the potential for contention and controversy from a public

1. For the purposes of this paper, "nanofoods" refer to foods and food packaging produced using nanotechnology.

acceptance perspective. Recent studies suggest that while there are relatively high levels of public awareness of GM foods (Rollin et al., 2011), there are low levels of awareness of food irradiation (Gunes & Tekin, 2006; Frewer at al., 2011) and nanotechnology (Kahan et al., 2007; Gaskell et al., 2010). Although these technologies differ in terms of public awareness, techniques applied and their duration of application, they face many similar challenges in terms of gaining public (consumer) acceptance.

The primary aim of this research was to explore how citizens form evaluations on (formations of attitudes around) NFTs. Individuals' construction of meanings around and interpretation of information about NFTs is explored, i.e. how attitudes form and change. This research therefore provides insights into how new information is used and assimilated and the implications of this on attitudes and acceptance.

In the following sections, the methodological approach is summarised and the research findings are presented. Drawing on these findings, the paper concludes with a discussion regarding public evaluations of NFTs and implications for communication strategies.

2. Methodology

This research applies a qualitative approach, which offers *"a multilayered view of the nuances of social reality"* (Hesse-Biber, 2010: 456), to delve more deeply, and thus provide greater insights into evaluative processes and reactionary responses towards

potentially contentious NFTs as information is presented to citizens. It thereby illustrates the complexity and conundrums associated with these evaluative processes.

To appreciate the significance of the different features framing citizens' evaluations of NFTs, a research approach that allows for the unfolding of participants' evaluative processes was applied. Of particular interest was to ascertain how citizens form opinions, i.e. their evolving perspectives, as information was presented. Thus, observations of one-to-one deliberative discourses (a structured, interactive conversation during which a question or issue is discussed in detail) between a food scientist and citizens, where they discussed a NFT, formed the basis of this enquiry.

This approach was essentially a dialogue between those directly involved in the production of knowledge and the audience for whom meanings associated with this knowledge are just as, if not more, important that the knowledge itself. Scientists' involvement in the process meant that any questions posed by participants about the technology could be responded to and expanded upon. The scientist's involvement also guided individuals towards more reflective types of responses. The discourse approach enabled a detailed exploration of both the cognitive and affective responses framing citizens' evaluations, rather than establishing overall general opinions about the technologies across a large sample group. The approach therefore provided depth rather than breadth in terms of examining citizens' evaluations.

As described by Merriam (2009: 13), researchers operating in the qualitative sphere are primarily interested in *"understanding the meaning people have constructed, that is,*

how people make sense of their world and the experiences they have in the world". Posing explicit questions results in rational reason-based responses which may conceal *"not only the symbolic but also the emotional and experiential material that drives cognition and behaviour"* (Joffe, 2011: 212). This approach moves away from the quantitative positivist approach as well as the more traditional in-depth interview, where a direct "questioning and answering approach" often forces participants to provide polarised answers. The discourse approach supported more reactive and reflective types of responses by participants; it also facilitated two-way interaction with questioning by participants, rather than just the interviewer.

For each technology, a scientist with relevant expertise was selected to participate; each scientist participated in a minimum of five discourses. Citizens were recruited from the general public based on pre-defined criteria presented in a screening questionnaire. The sample included a mix of socio-demographic backgrounds; ages ranged from 20 to 64 and occupations ranged from students to retirees. Individuals were only recruited if directly involved in food purchase decisions; as these individuals can influence the food consumption decisions of their households and are more likely to have formed opinions about food. Other recruitment criteria included not being employed within the food sector and displaying moderate to high level of generalised self-confidence, thus increasing the likelihood of good interaction with the scientist.[2] At screening, citizens were also asked several questions about their levels of subjective knowledge and

2. Questions posed were adapted from a scales developed by Day and Hamblin (1964).

concern about food production and processing, to ensure a variety of perspectives among participants. A monetary incentive (€50 payment) was provided to participate. Ethical approval to undertake this research was received from UCC Social Research Ethics Committee.

In total, 17 citizens participated; seven participated in the nanotechnology discourses, five in the GM discourses and five in the irradiation discourses. The number of participants was pre-defined at 17 to increase the likelihood of reaching theoretical saturation, which Bertaux (1981) and Guest et al. (2006) suggest is reached by analysing 15 and 12 in-depth interviews respectively. We found that having analysed 14 of the discourse transcripts, no additional themes emerged in terms of the common features influencing and directing evaluations across the set of potentially contentious NFTs, i.e. theoretical saturation was achieved.

In addition to the deliberative discourse, participants completed pre- and post-discourse interviews (the latter averaging 25 minutes in length) with the researcher, to determine their knowledge before and perspectives after participating in the discourse. The post-discourse interview was an effective means of member checking participants' views. Overall, this multi-method approach involved three interactions with each participant. A detailed "discourse guide" was prepared for the scientists to help them to navigate through the discourse process and to ensure consistency, i.e. a similar structure and context, across the discourses. The guide provided the framework for the two-way

discussion, within the boundaries of ensuring certain information on the technology was communicated.

A pre-discourse interview was undertaken with participating citizens to establish their knowledge of and attitudes towards the relevant technology. Participants were not informed about the technology in advance to control for proactive information searching. As public awareness of NFTs is generally low (Macoubrie, 2006; Kahan et al., 2007; Fell et al., 2009); the citizens were given a summary sheet to read, immediately prior to the discourse. This summary sheet included some factual (neutral) information about the technology, thereby ensuring that participants had a minimum standard level of information and basic awareness about the technology in advance of the discourse.[3] During the discourse, the participant considered the initial information provided and questioned the scientist regarding this. The scientist then added information that the participant reacted to and reflected on. An excerpt from one of the discourse transcripts in included in Appendix 1 to illustrate the format of the interaction.

In considering the influence of potential 'bottom-up' features on evaluations of NFTs, the scientists presented a number of pre-defined hypothetical, albeit topical, scenarios of applications of the relevant technology.[4&5] Naturally, the focus of the

3. The summary sheets were piloted on a range of individuals from different socio-demographic backgrounds to ensure clarity and comprehension and circulated to the relevant participating scientist for review and comment. The summary sheets are available on request from the authors.
4. The scenarios were developed following a review of literature, project team deliberation and consultation with the participating scientists. The hypothetical scenarios are available on request from the authors.
5. The scientists stressed that the scenarios were hypothetical to ensure participants understood that the risks and benefits presented were only discussion points and some of the product examples are not available on the market at present.

discussion within each discourse group centred on the attributes most relevant to the scenarios presented. Importantly, all scenarios (summarised in Table 1) incorporated hypothetical benefits, negative aspects and known and unknown risks of different applications of the NFTs from a consumer, societal, environmental and industry perspective.

Table 1: Overview of Scenarios of Food Applications of the Technologies Presented to Citizens

	Nanotechnology Discourses	**Genetic Modification Discourses**	**Food Irradiation Discourses**
Scenario 1	Food processing: removing unhealthy ingredients without compromising taste	Food processing: using a GM processing aid in cheese production in place of rennet	Irradiating fresh fruits and vegetables (at low doses) to prolong shelf life
Scenario 2	Food processing: adding healthy ingredients without compromising taste	Agricultural production: growing GM wheat crops	Irradiating spices (at low-medium doses) to kill insects/ reduce micro-organisms and bacteria
Scenario 3	Food packaging: to increase shelf life and indicate food spoilage etc.	Animal production: breeding a GM pig that is healthier and more environmentally friendly	Applying irradiation (at medium doses) to meat products to kill disease causing micro-organisms (e.g. E-coli)
Scenario 4	Food production: nanocoatings on machinery to increase food safety and reduce the need for cleaning agents	Food production: enhancing food products (e.g. the shelf life and health characteristics of fruits) through genetic modification	Applying irradiation (at high doses) to sterilise foods for consumption by specific consumer groups

Citizens were probed (see Table 2) at each stage of scenario expansion to ascertain their evolving evaluative processes in light of additional information.

Table 2: Examples of Questions Posed to Citizens during the Presentation of the Scenarios of Different Applications of the Technology

Based on this additional information:
• What is your opinion about using the technology in this way? Why do you feel like this? • Would you be open to the supply of this type of food product in Ireland? • Would you have any concerns about this type of food product? • What kinds of people do you think would be interested in such food products? • Has this additional information modified your views in any way? • How should such products be regulated in your opinion? • How important do you consider the labelling of these types of food products to be? • In your opinion, should industry adopt this technology?

The lead researcher observed the discourses, as a non-participant. Two pilot discourses were completed; debriefing interviews confirmed that the proposed format of the discourse was appropriate, i.e. elicited adequate information. As no significant alterations were made to the approach, the pilot data are included in this analysis. Each discourse, ranging from 40 to 65 minutes in length, was audio recorded and later transcribed verbatim by a commercial transcription company, including features potentially pertinent to interpretation of the transcripts (e.g. pauses and laughter).

Detailed thematic analysis was undertaken on the discourse and interview transcripts with the support of a qualitative software package (NVivo9), following the approach of Braun and Clarke (2006). Thematic analysis involves identifying, coding, analysing and reporting themes within the data and interpreting these emerging themes in the context of the research questions. Several transcripts were independently coded by members of

the research team to ensure that no relevant codes or themes common across the NFTs had been overlooked. The involvement of researchers with a variety of perspectives (i.e. backgrounds in consumer behaviour, risk communication, economics and nutrition) strengthened the internal validity and reflexivity of the analytic process (Jootun et al., 2009), minimising any potential interpretative bias. All codes and potential sub-themes were grouped together and reviewed for consistency, variability and emergent patterns as part of a consultative process. This iterative analytic process ultimately led to the emergence of the themes outlined.

3. Findings[6]

Key themes, summarised in Figure 1, emerged in terms of the common features influencing and directing evaluations across the NFTs. The first theme relates to the personal orientations that provide the basic framework for individuals' interpretation of information about and, in turn, evaluations of the technologies. The second theme relates to individuals' perceptions of power and control; specifically how uncertainty, information requirements, trust and regulation impact evaluations. The third theme, "perceived relevance", concerns the impact of perceived benefits and risks on evaluations. As a final stage of evaluations, "making sense of technologies" concerns

6. Quotations from the deliberative discourses and interviews have been edited and irrelevant exclamations and repetitions are omitted. The omission of words or sentences (undertaken to condense quotations and only when such editing did not alter the meaning of the quotation) is indicated with a bracketed ellipsis: (...). An ellipsis without brackets indicates a pause. Finally, text presented in square brackets represents implicit parts of the conversation, expressed in the preceding discussion.

the meanings and associations individuals construct when classifying and interpreting information about the technologies. These "meanings" are formed and created by the influences represented in the other themes.

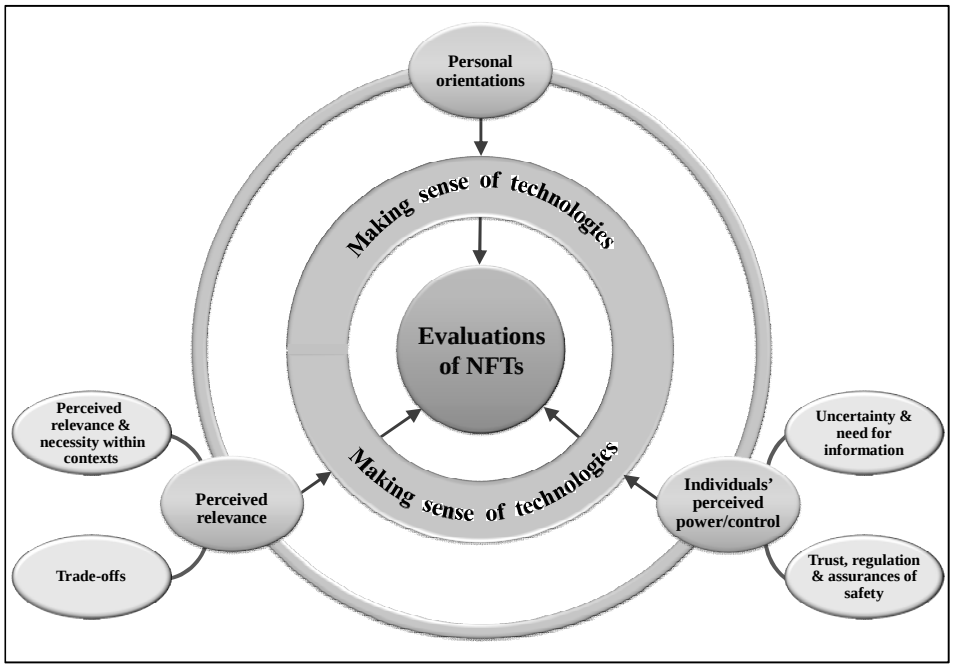

Figure 1: Features Influencing Evaluations of Novel Food Technologies

Theme 1: Personal orientations

This first theme, personal orientations, represents the expression of individuals' inner sense of standards. Initial reflections on the technologies are based on what is valued and whether or not the technologies violate these standards or undermine core values/ beliefs. Personality traits and value orientations provide the framework for responses to information about the NFTs and are the foundations for both emotional reactions and

reasoned responses. In particular, attitudes to nature, science and technology and general risk sensitivity play important, and sometimes conflicting, roles in forming perspectives.

A protectionary stance in terms of man's relationship with nature aligns to general risk sensitivity around food production. Furthermore, this can manifest as moral and ethical objections to the technologies and as a form of food anxiety. Those who view nature as fragile and value the protection of nature worry about the content of food and the potential consequences of applying NFTs: *"Man is always trying to control things. But there's always something that will actually out win us in the end you know…surpass us some way or other. (…) We have a responsibility (…) so how far do you go? (…) There's huge possibilities but there are huge issues. (…) "I think that extreme caution has to be exercised"* (Nano3). The sense of unease around the development of the technologies is evident in the precautionary stance displayed and questioning as to where the limits lie in terms of humans' interference in nature.

In contrast, a strong belief about man's dominance over nature leads to open enthusiasm for the technologies, less risk sensitivity and a more *lassiez-faire* perspective in terms of evaluations: *"We will never get anywhere if we are just going to be afraid of everything. (…) There's a risk with everything isn't there…"* (Nano4). Equally, focusing on outlooks towards science and technology, those reacting positively towards the NFTs often portray themselves as techno-enthusiasts, supportive of technological progress: *"I think it's far better to have the technology than not. Because who knows what else it*

will lead onto?" (Nano1, Post-Discourse Interview). That said, for those whose beliefs centre on maintaining traditions and natural processes, these beliefs are in conflict with a desire to support the fostering of scientific progress and developments.

Life experiences offer a mechanism for processing information, and existing understandings of one's social world is a platform for interpretation of the technologies. Thus, the internalised sense of "standards" that supports initial evaluations is based on factors such as work roles, educational experiences, family lifestyles and health experiences. Here, evidence of professional experience aligns with value orientations towards health and long term effects: *"You see that's my own [nursing] background….my own profession. (…) I would be more kind of about (…) long term health. So I would be kind of worried about that [GM foods]. (…)The long term effects (…) I would mind if it [genetic modification] was in most of the food out there"* (GM1).

Individuals use technical terms associated with their professions to anchor their evaluations, drawing on existing views from their "professional worlds" to create meanings and associations. Specifically, business professionals (e.g. accountants) draw on these prior experiences, referring to economic impacts of adopting the technologies on food prices, suppliers, and stock and export levels; while caregivers (e.g. social workers) focus on potential enhanced safety characteristics associated with their application: *"I suppose from… the suppliers point of view they have a little bit longer to get rid of the stock [by prolonging shelf life through food irradiation] (…) I suppose I am just thinking like an accountant you know"* (Irradiation3).

Personal orientations, which represent expressions of an inner sense of standards, are clearly drawn upon to form initial evaluations. Perceptions of the technologies violating these "standards" may lead to the demand for both a precautionary approach and control over exposure to the technologies.

Theme 2: Individuals' perceived power/control

Two types of uncertainty, knowledge and scientific, are observed that result in distinct responses. While knowledge uncertainty results in the demand for further information and impacts the stability of emerging attitudes, the existence of scientific uncertainty is the basis for immediate reassessment of one's position. Expressions of dread are closely related to knowledge uncertainty and lack of personal control over potential hazards. Trust in science and regulatory frameworks are therefore considered important where personal control is perceived to be lacking.

Uncertainty and need for information

Scientific uncertainty communicated about potential hazards negatively influences technology evaluations: "*I suppose that's the reason why the whole world is half afraid of those two words, genetically modified…that we don't know what it's going to bring about*" (GM3). This uncertainty impacts the stability of attitudes: *"You see until you told me about those particles…I was grand. But now that I am thinking about them. (…) I wouldn't deliberately buy something that I know would have particles that may lodge in my body or my friends or my family's"* (Nano3). Knowledge uncertainty clearly

moderates evaluations: *"I don't think I would have a problem in eating it [irradiated food]. But I suppose I am a bit ignorant to it in that I don't understand it. (…) How it could be harmful in some way?"* (Irradiation1). While initial evaluations are often fashioned by personal orientations, a tendency towards lower concern is evident in cases of low levels of perceived knowledge uncertainty. In particular, the prolonged debate and media discourse around GM foods contribute to a less anxious response: *"10 years ago I would have been horrified…I would have actually been very emotional about it. I would have said 'absolutely not'. (…) I mean as the years go on, I am getting less and less against GM"* (GM3, Pre-Discourse Interview).

The lack of evidence of associated dangers supports positive evaluations: *"There's no stories coming out saying that these [GM] foods are harmful. (…) I don't see the harm in them at the moment"* (GM2). In the case of a long established NFT that has received little media attention, the duration of its existence is taken into account: *"I think after 30 years we might know that something was particularly bad"* (Irradiation2). However, limited exposure to discussion about this technology results in a general sense of dread around the technology. Overall, knowledge uncertainty results in a precautionary stance being taken: *"You would need information on it. (…) If I just saw nanotechnology I'd kind of…just wonder what's it about"* (Nano2). A need for further information is therefore evident; there is a general consensus that the public *"wouldn't have a clue"* (Irradiation1) about these NFTs and that accessible information is therefore *"key (…) [in order to] take the fear and the uncertainty away"* (GM2).

The importance of openness and transparency is stressed in situations where uncertainty persists about potential associated risks: *"If you don't know…the repercussions of certain things then you have to be honest with the public"* (Nano7). A demand for personal control and freedom of choice frame evaluations. Thus, acceptance, while not guaranteed, is conditional on the provision of comprehensive information, such as label information, that allows individuals to make informed voluntary choices: *"I would think a majority of consumers would want to know …where their food has come from like and what it's gone through"* (Irradiation1, Post Interview). However, it appears the demand for information may not be ubiquitous: *"It wouldn't bother me (…) the fact that it was…the food was irradiated (…) I wouldn't see a need for labels"* (Irradiation3). Therefore, while some attempt to limit knowledge uncertainty through information seeking, others use heuristics and tend to display emotional reactions.

Trust, regulation and assurances of safety

Trust in scientists and regulators to control any potential technological risk acts as a heuristic in guiding evaluations: *"From a consumer point of view like, if I went into a supermarket and something is on the shelf I would just presume that it has been passed by all the… authorities that say right, this can be sold here, there's nothing wrong with it, it's safe"* (Irradiation5). Individuals' perceptions of low personal control/power are offset, to varying degrees, by their trust in other stakeholders to ensure protection against potential risks. Desiring personal control over exposure to such risks is tempered

with a recognition that this had to be ceded to regulators, due to perceived personal inability to assess safety risks.

However, concerns with safety are pervasive and evidence of the need for a precautionary approach is, once again, evident: *"It's all about being tried and tested"* (Nano4). The need for adequate regulation, transparency and risk assessments is stressed and *"rigorous testing"* and safety assurances are demanded. In fact, positive evaluations are based on the assumption that the NFTs will be adequately regulated.

Perceived uncertainty clearly impacts evaluations with knowledge uncertainty influencing the stability of attitudes and scientific uncertainty forming the basis for a cautious response. This uncertainty is closely linked to control in the context of information requirements, trust and regulation.

Theme 3: Perceived relevance

Individuals classify NFT products based on their views of the technologies and benefits offered. Following this, they negotiate these products based on the prioritisation of values in given contexts, in order to shape overall evaluations. While guided by individuals' personal orientations, the perceived relevance of benefits offered by foods produced using NFTs also impacts perspectives. Foods classified as offering value on dimensions considered important in given contexts are received more favourably: *"If it's prolonging the shelf life and (…) if there's other health benefits there as well then…I would be all for it [food irradiation]"* (Irradiation3). The most notable of these

are health, taste, price, safety and shelf life characteristics. Evaluations are generally positive in cases where current offerings on the market place are seen as sub-optimal, and the technologies offer an alternative that eliminates perceived sacrifices between highly valued attributes, particularly health and taste. This theme addresses the concept of perceived relevance and necessity within different contexts. Following this, it examines the formation of perceived risk/benefit trade-offs and their impact on evaluations.

Perceived relevance and necessity within contexts

The perceived relevance of related product benefits to the individual, their family, society, the environment and other stakeholders, and the perceived necessity of the technology applications, impacts openness to the technology. This openness, however, depends on individuals' overall values and priorities. For example, some feel that, subject to any associated risks being adequately addressed, NFT foods that can enhance the health of the nation should be welcomed: *If it [a health promoting nanofood] will improve people's lives, well and good"* (Nano3). In fact, if societal benefits are viewed as great enough, personal reservations are set aside and, while not necessarily willing to purchase such products, they believed that they should be made available: *"For myself (…) I wouldn't like that [GM crops]. But again I am also aware of (…) the third world countries…poverty and all that. (…) I can see how they would benefit…But I wouldn't benefit from it really"* (GM3).

Those voicing concerns about the impacts of human behaviour on the environment appear open to applications that offered environmental benefits. Furthermore, the suggestion of any environmental risks causes these individuals to negatively reassess their evaluations: *"If it did have negative effects on the surrounding environment (…) it would put me off it…I would see that as dangerous"* (GM1). Those holding a more *lassiez-faire* attitude towards the environment are less exercised about environmental benefits and also less concerned about potential environmental risks. Finally, although the potential impacts of these NFTs on other stakeholders, including food companies and their employees and farmers were raised, such references are secondary to individual and familial implications: *"It [potential impacts on food companies and their employees] wouldn't be as high on the list as knowing what I have on my plate or…what I give to whoever in the family is safer. (…)…that they are not going to get E-coli from me not cooking it very well"* (Irradiation2).

Not all applications are viewed as offering additional benefits, and in these cases, their necessity is questioned, in part due to the perceived adequacy of current food products. For example, some consider it unnecessary to enhance the health characteristics of fruit and vegetables, while others view food safety levels and/or shelf life to be at a satisfactorily high standard: *"I haven't heard of anybody who is dying or in serious trouble because of the way that they are producing food at the moment"* (Irradiation3). Closely aligned to the concept of perceived necessity, is that of perceived benefit distribution; benefits viewed as not accruing to individuals receive a more muted

response. For example, nano coating on equipment is perceived as "*really only of benefit to the manufacturer*" (Nano5). Relevance and necessity are linked to perceived trade-offs between benefits and risks and are context specific.

Trade-offs

Deliberation over potential risk/benefit trade-offs is central to product and application specific evaluations. These trade-offs are particularly evident when evaluating applications that offer increased food safety and extended shelf life. For many, perceived losses in terms of naturalness, freshness and healthiness of NFT products are weighed against the additional safety and/or shelf life benefits: *"I suppose if you have something for longer, you are going to accept that it's not going to be as nutritious as something you eat straight from the garden"* (Irradiation2). Compounding these trade-offs, and creating an element of tension, is the possibility of further benefits, related to reducing waste, for the environment and their wallets.

Price is another key element used in trade-off negotiations. Price premiums are often considered acceptable if related personal benefits are very apparent: "*In general, I suppose if the health benefits [of the nanofood] far outweigh the other products on the market then I think you would be happy to pay…"* (Nano1). These trade-offs are also considered in the context of others: *"I suppose for me it [the price premium] wouldn't really be a big issue, but I would suspect that for many people (…) [the] cost factor would be huge*" (Nano3). Some feel that although they might personally be willing to pay a price premium to avoid NFT products, given their lack of knowledge of

associated risks, they could also *"see why other people would go for it…if it was 10% to 20% cheaper"* (GM1).

Tensions are also apparent concerning these perceived trade-offs, particularly in terms of perceived benefits of such foods and concern over potential unknown future consequences of interfering with nature: *"If a pro is a rasher [from a GM pig] that tastes a little bit better (…) And the con is something really disastrous that we don't know about yet (…) It's hard to measure up the two things"* (GM2).

The emerging trade-offs derive from individuals' classifications of the technologies and related product characteristics, which are more broadly impacted by the personal orientations previously outlined. Furthermore, the dynamics of these trade-offs mould, in turn, how individuals create "meanings" around the NFTs.

Theme 4: Making sense of technologies

As a final stage of evaluations, "making sense of technologies" concerns the meanings and associations individuals construct when classifying and interpreting information about the technologies. These "meanings" are formed and created by a set of influences represented in the three other themes. Interpretative schemas, a term used by Scheufele and Tewksbury (2007) to describe knowledge structures that represent salient concepts, appear to be used by individuals to "make sense" of the technologies; essentially to shape evaluations. Both existing schemas, drawn upon from memory, and

newly formed schemas are created to provide links and associations and thus frameworks for the contextualisation of information.

Reasoned thinking acts as one of the mechanism for forming/creating these schemas around the technologies and prioritising risk and benefit assessments. In an effort to place the NFTs within a context, comparisons are often made to risks and benefits associated with other technologies and innovations. For example, comparisons are made between food irradiation and chemical fumigation and between BSE and genetically modifying animals: *"…definitely not [in favour of genetically modifying] my meat…because especially with mad cow disease… (…) I just think that animals….that meat could be even more dangerous for that reason"* (GM1). It should be noted that reasoned thinking, based on such comparisons, does not necessarily result in citizens reaching the same conclusions as scientists regarding their assessments of the technologies.

Evaluations of these unfamiliar technologies seem to be based on what is known. In fact, a tendency is evident to superimpose the NFTs on pre-existing interpretive schemas, e.g. irradiation to x-rays and cancer. In some cases, this may result in misinterpretation of the information presented. Word associations also support the formation of interpretative schemas. Specific images are generated by individuals around the technologies. For example, images conjured include: the *"injection of substances into food"* (genetic modification), "*tiny robots"* and computers (nanotechnology), and *"radiation"* (food irradiation). In fact, the image associations

and superimposed interpretative schemas are so strong for "irradiation" that they act as a particular barrier to acceptance: *"The name would kind of put you off a small bit. (…) It's just to get away from the…radiation…part of the name. (…) If it had a different name I think (…) it could take off in a big way"* (Irradiation3).

The unknown consequences of adopting the NFTs clearly play on individuals' minds: *"With technology like this…you have to go 30 years down the road before you realise the consequences"* (Nano5). In fact, such concerns lead to comparisons to risks now known to be associated with smoking, asbestos, excessive use of x-rays and some food colourants; generally these comparisons raise concerns. That said, reflections around established food technologies (e.g. microwave ovens) appear to cause a positive re-evaluation of initial negative opinions and "intuitive" stances on the NFTs: *"Microwaves seem safe enough (…) I suppose it's a similar enough technology…in a way. And if (…) it's prolonging the shelf life (…) I would be all for it"* (Irradiation3). In fact, an internal tension is evident, with concern about these technologies being set against evidence of the success and benefits of more well-established food technologies: *"Now…I would much prefer to buy pasteurised milk rather than unpasteurised milk. So it [nanotechnology] may go the same way you know"* (Nano3, Post Interview). Indeed, while desiring a precautionary approach, it is suggested that it is *"unfair"* that these NFTs have to *"prove"* themselves through testing, while technologies already in use do not: *"We don't know the effects of the old stuff either (…) It would be slightly unfair to suddenly say it's the new stuff causing the problems"* (Nano6).

While evaluations often appear to be based on the use of interpretative schemas, emotive reactions are also displayed in an effort to "make sense of technologies", particularly when personal orientations guide evaluations. Affective reactions appear particularly dominant when individuals lack, or perceive themselves to lack, the ability or motivation to understand the information presented, particularly the scientific knowledge to justify their negative opinions: *"It's lack of knowledge linked with this. (…) So fear comes in or some pre-conditioning"* (Nano3). Individuals display both *"rational"* and *"logical"* responses guided by reflective processing and also "*emotional response[s]"* and *"gut reactions"*: *"I have no scientific basis. But…just an intuitive sort of suspicion and fear…because you can do what you want to wheat but…when you are getting closer to living things…"* (GM2).

Internal conflicts emerge when the aforementioned influences come together to shape and support the construction of scaffolds of "meanings". Specifically, tensions are evident in terms of conflicting reactive (i.e. emotional) and reflective (i.e. reasoned) responses. Concerns are voiced about the NFTs, while their applications are concurrently viewed as *"reasonable"* and *"rational"* (Irradiation2). A further conflict is evident in terms of adopting a precautionary position due to scientific uncertainty and the desire to encourage technological process: *"Nobody can predict what's going to happen tomorrow let alone in 100 years time. So…it's very unfair to put a stop on it because someone says in 100 years time it could be bad"* (GM5).

The meanings constructed, and in turn evaluations of the technologies and associated risks and benefits, are not homogenous across the sample. Unique "rule books" of acceptance are formed, shaped by the influences represented in the other themes. A key component of such rule books is individuals' classification of the applications and products and the associated meanings reflected upon when forming evaluations. For example, individuals' personal rule books may vary in terms of what they perceived as natural; i.e., some consider GM foods to be an acceleration of a natural process "*just on a more fundamental level"* (GM2), while others view it as unnatural: *"When you can grow it [GM crops] anywhere (…) it's not natural (…) I don't think it's right to have wheat growing somewhere where you wouldn't normally have it"* (GM1). Furthermore, as part of this rule book, individuals display what Hallman (2000: 15) refers to as a *"hierarchy of approval"* in terms of their acceptance of the applications, based on the aforementioned influences. Specifically, irradiating meat to increase food safety is generally considered more acceptable than irradiating fruit to prolong shelf life. GM plant applications are also considered more acceptable than GM animal applications, due, in part, to perceptions of unnaturalness. These rule books are an important "tool" drawn upon to provide a scaffold for contextualising information and constructing meanings around the technologies.

4. Discussion and conclusion

In this paper, we focused on how the processes involved in citizens' evaluations of NFTs occur as information is assimilated. We contend that "making sense of technologies" involves the use of interpretative schemas (Goffman, 1974), including both existing schemas, drawn upon from long-term memory (Peter et al., 1999), and newly formed schemas that are created to provide the framework for individuals' contextualisation of information (Gamson et al., 1992). Personal orientations result in the formation of inner "standards" which provide a strong basis for making sense of technologies by providing existing schemas upon which to form opinions. Perceptions of the technologies violating these standards may lead to the demand for a precautionary approach. Perceived control and trust in science and regulators are a basis for attitudes to change if any scientific or knowledge uncertainty transpires; if trust exists; the extent of attitude changes due to new information may be moderated. Openness to the technology is therefore influenced by trust and perceived control; the lower the trust level, the more cautious a person is with regard to the technology. The perceived relevance and necessity of the applications and associated products to a person's everyday life and important values provides a platform for evaluations. Such relevance and necessity are linked to perceived risk/benefit trade-offs within specific contexts.

Personal orientations and comparisons to other technologies are important in providing what Burri (2009: 507) refers to as *"interpretative patterns that served as tools in decision making"* in terms of evaluations of nanotechnology. We observe that

the processes through which citizens “make sense of technologies” occurs at both reflective and shallow levels, depending on personal orientations, the specific technology and perceived uncertainty and control. The impact and relevance of information on evaluations varies, depending not only on the technology, but also the specific application and product in question (as postulated by Fell et al., 2009 and Rollin et al., 2011) and individuals’ characteristics and interpretations of information. Our analysis suggests that personal orientations (top-down characteristics) impact evaluations and in keeping with the work of Bredahl (2001) and Grunert et al. (2003), specific product characteristics (bottom-up characteristics) are also influential. In the context of classifying product characteristics, Furst et al. (1996) draw attention to the processes enacted by individuals during the emergence of their food choice trajectories, suggesting that individuals prioritise values; classify foods based on these values in given contexts; and, then select foods in accordance with these. The product fit at a practical and conceptual level within a person’s life will result in either an outright rejection of the technology, acceptance of the technology but rejection of related products, or acceptance of the technology and acceptance of resultant products.

Although individuals may form similar technology assessments, they often draw on different rationalities and contexts in guiding their evaluations and interpreting information. This highlights the need to understand, not only overall assessments but also the processes contributing to such assessments. In terms of the evolution and stability of attitude formations, some citizens appear to be stronger in their convictions

and initial attitudes, while the evaluations of others are more malleable. As a result of this malleability, new information leads to re-evaluations. That said, initial attitudes seem to guide further evaluations and bias the processing of subsequent information.

Need for cognition appears to vary, with some relying more on heuristics than others. These individuals are, in effect, *"cognitive misers"* (Scheufele & Lewenstein, 2005: 660), exhibiting limited effort and interest in acquiring and processing relevant information. While they recognise that they are unfamiliar with the processes that the foods they consume undergo, they are not actively searching for information about these processes, particularly if they place high levels of trust in the regulatory system.

This analysis highlights the complexities, conflicts, contradictions and conundrums evident in terms of citizens' evaluations, which may in some instances result in attitude ambivalence. While minimal attention has been paid to the conflicts that manifest in terms of elements associated with evaluations of NFTs, Rowe (2004) speaks of such complexities, highlighting the challenges they create in terms of developing relevant communication strategies. These internal conflicts are created, to a large degree, due to personal orientations and product relevance anomalies. While embracing the related benefits offered, a cautious stance is adopted about potential associated risks and the necessity of some applications is questioned. Furthermore, internal conflicts are evident in terms of reactive (linked to the emotions) and reflective (linked to cognitive information processing) responses (Ortony et al., 2005); with the latter potentially

resulting in the former being “rationalised” to the point of internal dismissal. Such internal conflicts appear on-going and there is a broad spectrum upon which they exist.

Perceived risks and uncertainty create a sense of dread which weighs considerably on overall evaluations, often resulting in the adoption of a precautionary stance based on “intuitive” (emotive) reactions. In spite of welcoming potential associated benefits, citizens display a tendency to revert back to this precautionary position, due to lack of knowledge and perceived uncertainty. Rollin et al. (2011) and Hagemann and Scholderer (2009: 1043) speak to this when discussing the role that perceived uncertainty can play as a *“driving force”* behind consumer evaluations, stating that general perceived uncertainty, rather than specific risk perceptions, can lead to technology resistance.

Acceptance appears an evolutionary rather than a revolutionary process. This is of course, unless significant, unique, tangible benefits of relevance are apparent. As Bruhn (2007) highlights, consumers seek products with explicit tangible benefits rather than specific technologies. Therefore, if an objective of a communication is to successfully market and sell related products, companies should anchor benefits of the products in concrete examples of product characteristics relevant to individuals’ demands from food (Siegrist, 2008).

Many challenges are associated with engaging with the general public about these technologies (Bostrom & Lõfstedt, 2010), as levels of knowledge, understanding and interest vary considerably. Oversimplified assumptions about citizens’ attitude

formations and acceptance may lead to counterproductive communication strategies (Wansink & Kim, 2001). Industry, policymakers and other institutions involved in food communications should take account of the numerous and varied existing schemas drawn upon when evaluating food applications and related products; which potentially lead to misinterpretation of the processes that food undergoes.

Within any public communication about NFTs, openness and transparency are necessary (Einsiedel & Goldenberg, 2004; House of Lords, 2010), particularly in the face of uncertainty. As the findings indicate, public confidence in the implementation of adequate regulations and risk assessments in order to guarantee safety is essential (Simons et al., 2009). The media's continued role in influencing public attitudes, both positively and negatively should not be underestimated (Scheufele & Lewenstein 2005; Dudo et al., 2011). In addition to focusing on awareness and engagement, relevant stakeholders, particularly policymakers, should take account of the broader determinants influencing attitudes towards NFTs, including attitudes towards science, technology and nature.

Although these findings are not generalizable, diversity and complexity in terms of the features influencing citizens' evaluations is apparent. The outcomes observed may be influenced to varying degrees by the information presented, i.e. the applications and associated risks and benefits, and the interpersonal dynamics, i.e. rapport and trust, between the scientists and citizens. However, the breadth of observations in terms of citizens' responses militates against this eventuality. Not surprising, given the screening

for generalised self-confidence, all participants appeared to be relatively confident in engaging with the scientist. Finally, citizens' reactions towards the hypothetical foods discussed were situated in the absence of real life purchase/consumption decisions. This interaction allowed for more deep information processing about abstract situations.

To conclude, a review commissioned by the FSA, UK (Fell et al., 2009: 54) stresses *"the lack of good qualitative work examining the links between underlying values, expressed attitudes and actual behaviours"* in terms of NFTs and the necessity to understand how these elements interact in order to *"gain a full understanding of public perceptions"*. This qualitative research contributes to the body of evidence within this area. Specifically, it provides insights into citizens' evolving evaluative processes, illustrating the complexity and conundrums in their thinking, which may in turn present as attitude ambivalence. Furthermore, it draws attention to the on-going necessity to qualitatively investigate, as well as quantitatively confirm, citizens' attitude formations towards, in addition to assessments of, these technologies; as the stability of such attitudes cannot be assumed.

Appendix 1: An Excerpt from a Nanotechnology Discourse Transcript with a Female Participant (late 60s, retiree)

Nano Scientist	I'll talk a bit about what…what I…I am doing and I have been doing so far. (…) Then I might ask you just to introduce yourself, what…what your background is. I'll give you a bit of an introduction on nanotechnology. And then Gráinne prepared four scenarios…imaginary really you know. And we just talk about that…and just want to get your opinion on it and …positive or negative it doesn't…it doesn't really matter to me. It doesn't …I am not advocating nanotechnology.
Nano Citizen 3	Yes.
Nano Scientist	I just try to inform you about it you know. And maybe pros and cons and…just get your opinion on it, you know. Is that OK with you?
Nano Citizen 3	That's grand.
(…)	*[The scientist and citizen then each give a brief introduction of their background (where they come from, their occupation etc.) to each other]*
Nano Scientist	Alright, so you read a little bit of the background [summary sheet] of nanotechnology?
Nano Citizen 3	I did…I read it…yes, yes.
Nano Scientist	Did you hear anything about …what…what is your….knowledge before?...
Nano Citizen 3	Well I was telling Gráinne when I came in first nanotechnology….I thought it was something to do with computers and with mobile phones. Like I didn't know what it was after that.
Nano Scientist	Yes…yes…you are not far wrong…of….you know, you are not….
Nano Citizen 3	I thought…maybe first of all I thought it was a new game…you know. (…) I hate computer games…and all those things. It's like noise….Oh it is another gadget.
Nano Scientist	Yes, yes.
Nano Citizen 3	And I thought maybe it would be something a child would have now (…) …another gadget you know. But I …that…that was the limit. I would never read anything about it. I wouldn't read a magazine or ….a technical magazine or anything like that.
Nano Scientist	…you haven't heard of nanotechnology in food in one sentence have you?
Nano Citizen 3	No, I hadn't really no.
Nano Scientist	Yes, yes. Like in principle you are …not far off there. Because in the mainstream media that wouldn't be mentioned in one sentence really. Nanotechnology …as in nano…and the technology really…it comes from the technology background. Nano…do you know what nano is…did you ever hear?
Nano Citizen 3	It's tiny.
Nano Scientist	Tiny, yes, that's right. (…) I can give you a bit of background there. So a metre…you know what a metre is? Right?
Nano Citizen 3	Yes, yes.
Nano Scientist	…really a nanometre is one billionth of a metre. And nanotechnology, that's technology as such…or nanoscience, is the science of the small. That means it's nano scale. Anything from nanometre to micrometer….
Nano Citizen 3	How are you going to see it? What do you see it with?
Nano Scientist	You would see it in microscopy.
(…)	*[Following further discussion about nanotechnology and its potential applications, the scientist presented the four pre-defined hypothetical scenarios to the citizen]*

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